PATENT ABSTRACTS OF JAPAN

(11)Publication number : 11-037934
(43)Date of publication of application : 12.02.1999

(51)Int.Cl. G01N 21/27
G01B 11/00
G01B 11/26
H01L 31/00

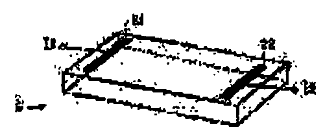
(21)Application number : 09-191496
(22)Date of filing : 16.07.1997

(71)Applicant : FUJI PHOTO FILM CO LTD
(72)Inventor : NAYA MASAYUKI

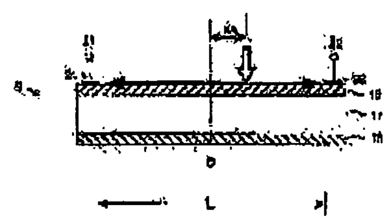
(54) SURFACE PLASMON SENSOR AND DARK-LINE LOCATOR

(57)Abstract:
PROBLEM TO BE SOLVED: To enhance the sensitivity by constituting a light detecting means of a light receiving face extending in the spreading direction of a light beam component totally reflected on an interface, and a photodiode having electrodes connected with the opposite ends thereof thereby enhancing the detecting speed.
SOLUTION: A light detecting means PSD comprises a light receiving face extending in the spreading direction of a light beam component which can receive each component of a light beam totally reflected on an interface, and a photodiode having electrodes 21, 22. More specifically, the PSD comprises three layers of P layer 16, N layer 17 and I layer 18 all components of a light beam totally reflected on an interface impinge on the P layer 16. Charges are generated from the impinging position of each component of an incident light beam and a photocurrent is divided in reverse proportion to the distance from each position to both electrodes 21, 22. Consequently, the sum of photocurrents generated by respective beam components is outputted from both electrodes 21, 22 while being divided. The total reflection attenuation angle is determined by locating a dark-line and a specific substance in a sample is analyzed quantitatively.

(a)



(b)



LEGAL STATUS

[Date of request for examination]	14.07.2000
[Date of sending the examiner's decision of rejection]	06.08.2002
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	

[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] A transparence substrate and the sensor unit which comes to have the metal membrane allotted to the 1 front-face side of this transparence substrate, The light source which generates the light beam which has the beam component of a large number which spread in the direction of one dimension, and said light beam so that incidence may be carried out by the incident angle from which this each beam component differs mutually to the interface of said transparence substrate and said metal membrane And the optical system which carries out incidence to this interface so that total reflection may be carried out by this interface, The light beam which carried out total reflection by said interface and which was equipped with a photodetection means to receive the light beam containing many beam components reflected by mutually different angle of reflection corresponding to said each angle of incidence, and carried out incidence to said interface detects the include angle which shows total reflection attenuation according to this interface. In the surface plasmon sensor which analyzes the sample allotted on said metal membrane The light-receiving side where said photodetection means can receive each beam component of the light beam which carried out total reflection by said interface and which extends in the direction of the breadth of this beam component, It consists of a photodiode equipped with the first electrode connected to the end of this light-receiving side, and the second electrode connected to the other end. Are dependent on the dark line location on said light-receiving side by the beam component which carried out incidence at the include angle which shows said total reflection attenuation of the light beam which is outputted from said the first electrode and second electrode, respectively, and which carried out incidence between said two electrodes. It has first operation means to ask for said dark line location based on the difference of the first integrated light current value of the photocurrent produced by this light beam, and the second integrated light current value. The surface plasmon sensor characterized by being what asks for the include angle which shows said total reflection attenuation from said dark line location called for by this operation means.
[Claim 2] The direction of the breadth of said beam component is made into x directions. The core between said two electrodes A zero, It is the photocurrent produced when a light beam carries out incidence of the distance between said two electrodes to per unit length of L and said light-receiving side I0 It carries out. When the output from said two electrodes when incidence is carried out to said light-receiving side in the condition that the component from which the light beam which carries out total reflection by said interface produces total reflection attenuation is not included is set to I10 and I20, respectively, the relation of these both outputs is [Equation 1].

$$I_{10} = I_{20} = \frac{L}{2} I_0$$

Said second integrated light current value I2 which is equipped with a positioning means to position said photodetection means before analysis of said sample so that said light beam by which total reflection was carried out may be received so that it may become, and is outputted from said first integrated light current value I1 to which said first operation means is outputted from said each electrode, and said second electrode ;

[Equation 2]

$$I_1 = \left(\frac{L}{2} - \frac{1}{2} + \frac{1}{L}x_A\right)I_0$$

$$I_2 = \left(\frac{L}{2} - \frac{1}{2} - \frac{1}{L}x_A\right)I_0$$

********, [Equation 3]

$$x_A = \frac{L(L-1)(I_1 - I_2)}{2(I_1 + I_2)}$$

By the becoming operation, it is the dark line location xA on said light-receiving side. Surface plasmon sensor according to claim 1 characterized by being that for which it asks.
[Claim 3] the direction of predetermined [of said interface] in a light beam -- difference -- with the first incidence impaction efficiency means to which the incidence location to said interface of this light beam is moved so that incidence may be carried out one by one in the state of the same incidence as a part It has first photodetection means migration means to which this photodetection means is moved so that the light beam which carries out total reflection by said interface may carry out incidence to said light-receiving side of said photodetection means to move with migration of the incidence location of this light beam. claims 1 or 2 characterized by measuring by scanning in one dimension in said predetermined direction about the sample allotted on said metal membrane -- either -- the surface plasmon sensor of a publication.
[Claim 4] the direction where a light beam intersects said predetermined direction of said interface -- difference -- with the second incidence impaction efficiency means to which the incidence location to said interface of this light beam is moved so that incidence may be carried out one by one in the state of the same incidence as a part It has further second photodetection means migration means to which this photodetection means is moved so that the light beam which carries out total reflection by said interface may carry out incidence to said light-receiving side of said photodetection means to move with migration of the incidence location of this light beam. The surface plasmon sensor according to claim 3 characterized by measuring by scanning two-dimensional in said predetermined direction and this predetermined direction, and the crossing direction about the sample allotted on said metal membrane.
[Claim 5] It has the first incidence impaction efficiency means it is made to move so that incidence may be carried out one by one in the state of the incidence as the part where the predetermined direction of said interface is different from each other with the same light beam. Said light-receiving side of said photodetection means is what is prolonged also in said predetermined direction. It is that to which said photodetection means equips the end of said predetermined direction with the third electrode, and equips the other end with the fourth electrode. The third current value depending on the incidence location of this light beam produced by said light beam which carried out incidence to inter-electrode [which are outputted from said third electrode / said / third and fourth]. It is based on a difference with the fourth current value depending on the incidence location of this light beam produced by said light beam outputted from said fourth electrode. claims 1 or 2 characterized by performing a 1-dimensional scan about the sample which is further equipped with second operation means to ask for the incidence location in said predetermined direction of said light beam which carried out total reflection, and is allotted on said metal membrane -- either -- the surface plasmon sensor of a publication.
[Claim 6] The core between M and these two poles is made into a zero for the distance between said two electrodes by making said predetermined direction into the direction of y. When the photocurrent produced when a light beam carries out incidence of said fourth photocurrent value outputted from I3 and said fourth electrode in said third current value outputted from said third electrode between I4 and these two electrodes is set to Iy0, The third and the fourth photocurrent value, [Equation 4] to which said second operation means is outputted from said each electrode

$$I_3 = \frac{1}{2}\left(1 - \frac{2}{M}y\right)I_{y0}$$

$$I_4 = \frac{1}{2}\left(1 + \frac{2}{M}y\right)I_{y0}$$

********, [Equation 5]

$$y = \frac{M}{2} \cdot \frac{I_4 - I_3}{I_3 + I_4}$$

The surface plasmon sensor according to claim 5 characterized by being what asks for the incidence location y in said predetermined direction of said light beam which carried out total reflection by the becoming operation.

[Claim 7] The surface plasmon sensor according to claim 6 characterized by performing a two-dimensional scan about the sample which is further equipped with the second incidence impaction efficiency means which makes the incidence location of said light beam to said interface move in said predetermined direction and the direction at which it crosses, and is allotted on said metal membrane by said first incidence impaction efficiency means and said second incidence impaction efficiency means.

[Claim 8] The light-receiving side which can receive each beam component of the light beam containing the beam component of a large number which spread in the direction of one dimension and which extends in the direction of the breadth of this beam component, The photodetection means which consists of a photodiode which equipped the end of this light-receiving side with the first electrode, and equipped the other end with the second electrode, Are dependent on the dark line location on said light-receiving side by the dark line component of the light beam which carried out incidence between said two electrodes outputted from said the first electrode and second electrode, respectively. Dark line location detection equipment characterized by consisting of an operation means to ask for said dark line location based on the difference of the first integrated light current value of the photocurrent produced by each beam component of this light beam, and the second integrated light current value.

[Claim 9] The direction of the breadth of said beam component is made into x directions. The core between said two electrodes A zero, It is the photocurrent produced when a light beam carries out incidence of the distance between said two electrodes to per unit length of L and said light-receiving side I0 It carries out. When the output from said two electrodes when incidence is carried out to said light-receiving side in the condition that the component from which the light beam which carries out total reflection by said interface produces total reflection attenuation is not included is set to I10 and I20, respectively, the relation of these both outputs is [Equation 1].

$$I_{10} = I_{20} = \frac{L}{2}I_0$$

The first [equipped with a positioning means / said] integrated light current value I1 by which said operation means is outputted from said each electrode in said photodetection means before said sample analysis so that it may become and said second integrated light current value I2 outputted from said second electrode ;

[Equation 2]

$$I_1 = \left(\frac{L}{2} - \frac{1}{2} + \frac{1}{L}x_A\right)I_0$$

$$I_2 = \left(\frac{L}{2} - \frac{1}{2} - \frac{1}{L}x_A\right)I_0$$

********, [Equation 3]

$$x_A = \frac{L(L-1)(I_1 - I_2)}{2(I_1 + I_2)}$$

It is the dark line location xA on said light-receiving side by the becoming operation. Dark line location detection equipment according to claim 8 characterized by being that for which it asks.
[Claim 10] It is that to which said light-receiving side of said photodetection means extends also in the direction of the breadth of said beam component, and the direction which intersects perpendicularly. It is that to which said photodetection means equips with the third electrode the end of said direction which intersects perpendicularly, and equips the other end with the fourth electrode. The third current value depending on the incidence location of this light beam produced by said light beam which carried out incidence to inter-electrode [which are outputted from said third electrode / said / third and fourth], It is based on a difference with the fourth current value depending on the incidence location of this light beam produced by said light beam outputted from said fourth electrode. claims 8 or 9 characterized by having further second operation means to ask for the incidence location in said predetermined direction of said light beam which carried out total reflection -- either -- the dark line location detection equipment of a publication.
[Claim 11] The core between M and these two poles is made into a zero for the distance between said two electrodes by making into the direction of y said direction which intersects perpendicularly. When the photocurrent produced when a light beam carries out incidence of said fourth photocurrent value outputted from I3 and said fourth electrode in said third current value outputted from said third electrode between I4 and these two electrodes is set to Iy0, The third and the fourth photocurrent value, [Equation 4] to which said second operation means is outputted from said each electrode

$$I_3 = \frac{1}{2}\left(1 - \frac{2}{M}y\right)I_{y0}$$

$$I_4 = \frac{1}{2}\left(1 + \frac{2}{M}y\right)I_{y0}$$

*********, [Equation 5]

$$y = \frac{M}{2} \cdot \frac{I_4 - I_3}{I_3 + I_4}$$

Dark line location detection equipment according to claim 10 characterized by being what asks for the incidence location y in said direction of said light beam which carried out total reflection which intersects perpendicularly by the becoming operation.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the surface plasmon sensor which has improved the photodetection means especially in the detail about the surface plasmon sensor which carries out quantitative analysis of the matter in a sample using generating of surface plasmon.
[0002]
[Description of the Prior Art] A free electron vibrates collectively in a metal and the compressional wave called a plasma wave arises. And what quantized this compressional wave produced in a surface of metal is called surface plasmon. The surface plasmon sensor which carries out quantitative analysis of the matter in a sample conventionally using the phenomenon in which this surface plasmon is excited by the light wave is proposed variously.
[0003] The analysis in a surface plasmon sensor is the following, and is made and made.
[0004] The slack sample for analysis is carried on the metal membrane allotted on the transparence substrate, and incidence is carried out so that total reflection of the light beam may be carried out from a transparence substrate side by the interface of a metal membrane and a transparence substrate to a metal membrane using predetermined optical system. If incidence of the light beam is carried out by the angle of incidence theta beyond a total reflection angle to a metal membrane, the "blot wave" called evanescent wave into the metal membrane of a reflector will arise. This evanescent wave has electric-field distribution in the sample which is in contact with this metal membrane, and surface plasmon generates it in the interface of this metal membrane and sample. If wave number adjustment is materialized equally to the wave number vector of the surface plasmon with the above-mentioned wave number vector of the evanescent wave which incidence of the light beam by which p-polarized light was carried out was carried out to the metal membrane, and it produced, both will be in a resonance state, luminous energy will shift to surface plasmon, and plasmon will be excited. At this time, the luminous intensity which carried out total reflection for shift of luminous energy falls remarkably. It is called total reflection attenuation that this reflected light reinforcement falls, and since it is a thing depending on the sample which is in contact with the metal, whenever [incident angle / at this time] (total reflection attenuation angle thetasp) can carry out quantitative analysis of the special material in a sample by getting to know this total reflection attenuation angle thetasp.

[0005] In order to obtain this total reflection attenuation angle thetasp, the reflectivity of the light beam which was made to carry out incidence of the light beam by various angles of incidence to the interface of a metal membrane and a transparence substrate, and carried out incidence by each of that angle of incidence is measured with a photodetector. Since the reflected light reinforcement of the beam component which carried out incidence at the include angle which produces total reflection attenuation is extremely low, the incidence location of this beam component serves as a dark line on the light-receiving side of a photodetector, and total reflection attenuation angle thetasp can be obtained from the dark line incidence location.
[0006] In addition, in order to acquire various angles of incidence, a comparatively thin light beam is deflected, incidence is carried out to the above-mentioned interface, the light beam which an

include angle may be changed one by one, or contains many beam components may be converged on the above-mentioned interface, and incidence of each beam component may be carried out to coincidence at an angle of a large number.

[0007]

[Problem(s) to be Solved by the Invention] In the above conventional surface plasmon sensors For example, the light beam from which angle of reflection changes with the deviation of a light beam And the area sensor prolonged along the change direction of angle of reflection detects, or [that the small photodetector which carries out a synchronized drive to the deviation of a light beam detects] Or the dark line location of a light beam reflected by the metal membrane was detected by the approach of area sensors, such as CCD prolonged in the direction which can receive the whole of each light beam reflected by various angle of reflection, detecting. In order for the whole equipment to become complicated in order to consider as the structure which scans a photodetector like the former, and to change whenever [incident angle], there is a fault that measurement takes time amount. Moreover, in using CCD like the latter, a limitation is in resolution, and there is a fault that follow on making it high sensitivity further, and a detection rate becomes slow. Thus, it was difficult to perform measurement which filled a high speed, high sensitivity, and an extensive dynamic range with the conventional detection approach to coincidence.

[0008] This invention is made in view of the above-mentioned situation, and aims at offering the total reflection attenuation measuring device with which a high speed, high sensitivity, and an extensive dynamic range are obtained.

[0009]

[Means for Solving the Problem] The sensor unit to which the surface plasmon sensor of this invention comes to have a transparence substrate and the metal membrane allotted to the 1 front-face side of this transparence substrate, The light source which generates the light beam which has the beam component of a large number which spread in the direction of one dimension, and said light beam so that incidence may be carried out by the incident angle from which this each beam component differs mutually to the interface of said transparence substrate and said metal membrane And the optical system which carries out incidence to this interface so that total reflection may be carried out by this interface, The light beam which carried out total reflection by said interface and which was equipped with a photodetection means to receive the light beam containing many beam components reflected by mutually different angle of reflection corresponding to said each angle of incidence, and carried out incidence to said interface detects the include angle which shows total reflection attenuation according to this interface. In the surface plasmon sensor which analyzes the sample allotted on said metal membrane The light-receiving side where said photodetection means can receive each beam component of the light beam which carried out total reflection by said interface and which extends in the direction of the breadth of this beam component, It consists of a photodiode which equipped the end of this light-receiving side with the first electrode, and equipped the other end with the second electrode. Are dependent on the dark line location on said light-receiving side by the beam component which carried out incidence at the include angle which shows said total reflection attenuation of the light beam which is outputted from said the first electrode and second electrode, respectively, and which carried out incidence between said two electrodes. It has further first operation means to ask for said dark line location based on the difference of the first integrated light current value of the photocurrent produced by each beam component of this light beam, and the second integrated light current value. It is characterized by being what asks for the include angle which shows said total reflection attenuation from said dark line location called for by the operation means of this first.

[0010] The core between said two electrodes is specifically made into a zero by making the direction of the breadth of said beam component into x directions. It is the photocurrent produced when a light beam carries out incidence of the distance between said two electrodes to per unit length of L and said light-receiving side I0 It carries out. When the output from said two electrodes when incidence is carried out to said light-receiving side in the condition that the component from which the light beam which carries out total reflection by said interface

produces total reflection attenuation is not included is set to I10 and I20, respectively, the relation of these both outputs is [0011].
[Equation 1]
$$I_{10} = I_{20} = \frac{L}{2} I_0$$

[0012] Said second integrated light current value I2 which is equipped with a positioning means to position said photodetection means before analysis of said sample so that said light beam by which total reflection was carried out may be received so that it may become, and is outputted from said first integrated light current value I1 to which said first operation means is outputted from said each electrode, and said second electrode ;
[0013]
[Equation 2]
$$I_1 = \left(\frac{L}{2} - \frac{1}{2} + \frac{1}{L} x_A\right) I_0$$

$$I_2 = \left(\frac{L}{2} - \frac{1}{2} - \frac{1}{L} x_A\right) I_0$$

[0014] ********, [0015]
[Equation 3]
$$x_A = \frac{L(L-1)(I_1 - I_2)}{2(I_1 + I_2)}$$

[0016] By the becoming operation, it is the dark line location xA on said light-receiving side. It can ask.
[0017] the direction of set in the above-mentioned surface plasmon sensor, and predetermined [of said interface] in a light beam -- difference -- with the first incidence impaction efficiency means to which the incidence location to said interface of this light beam is moved so that incidence may be carried out one by one in the state of the same incidence as a part It has first photodetection means migration means to which this photodetection means is moved so that the light beam which carries out total reflection by said interface may carry out incidence to said light-receiving side of said photodetection means to move with migration of the incidence location of this light beam. It may be made to measure by scanning in one dimension in said predetermined direction about the sample allotted on said metal membrane. A light beam is made to deflect according to the optical system equipped with the galvanomirror etc., an incidence location is moved, for example, it makes the light source and the optical system itself move mechanically, and may move [whose above "the first incidence impaction efficiency means" is] an incidence location like tele cent rucksack scan optical system. Moreover, the light source and optical system are [that migration of the incidence location to said interface of a light beam should just be performed relatively] good also as moving the incidence location of the light beam in an interface by fixing and moving the sensor unit itself.
[0018] moreover, the direction where a light beam intersects said predetermined direction of said interface -- difference -- with the second incidence impaction efficiency means to which the incidence location to said interface of this light beam is moved so that incidence may be carried out one by one in the state of the same incidence as a part It has further second photodetection means migration means to which this photodetection means is moved so that the light beam which carries out total reflection by said interface may carry out incidence to said light-receiving side of said photodetection means to move with migration of the incidence location of this light beam. About the sample allotted on said metal membrane, it may be made to measure by scanning two-dimensional in said predetermined direction and this predetermined direction, and the crossing direction.
[0019] Or it has the first incidence impaction efficiency means it is made to move so that incidence may be carried out one by one in the state of the incidence as the part where the

predetermined direction of said interface is different from each other with the same light beam. It is that to which said light-receiving side of said photodetection means extends also in said predetermined direction. It is that to which said photodetection means equips the end of said predetermined direction with the third electrode, and equips the other end with the fourth electrode. The third current value depending on the incidence location of this light beam produced by said light beam which carried out incidence to inter-electrode [which are outputted from said third electrode / said / third and fourth], It is based on a difference with the fourth current value depending on the incidence location of this light beam produced by said light beam outputted from said fourth electrode. It has further second operation means to ask for the incidence location in said predetermined direction of said light beam which carried out total reflection, and may be made to perform a 1-dimensional scan about the sample allotted on said metal membrane.

[0020] Said predetermined direction is specifically made into the direction of y. The distance between said two electrodes In this case, M, Said third current value which makes the core between these two poles a zero, and is outputted from said third electrode I3, When the photocurrent produced when a light beam carries out incidence of said fourth photocurrent value outputted from said fourth electrode between I4 and these two electrodes is set to Iy0, The third and the fourth photocurrent value, [0021] to which said second operation means is outputted from said each electrode in the incidence location y in said predetermined direction of said light beam which carried out total reflection

[Equation 4]

$$I_3 = \frac{1}{2}\left(1 - \frac{2}{M}y\right)I_{y0}$$

$$I_4 = \frac{1}{2}\left(1 + \frac{2}{M}y\right)I_{y0}$$

[0022] ********, [0023]

[Equation 5]

$$y = \frac{M}{2} \cdot \frac{I_4 - I_3}{I_3 + I_4}$$

[0024] It can ask by the becoming operation.

[0025] Furthermore, it has further the second incidence impaction efficiency means which makes the incidence location of said light beam to said interface move in said predetermined direction and the direction at which it crosses, and may be made to perform a two-dimensional scan about the sample allotted on said metal membrane by said first incidence impaction efficiency means and said second incidence impaction efficiency means.

[0026] In addition, the photodetection means of the surface plasmon sensor of above-mentioned this invention can also be used as a dark line location detection means to detect the so-called dark line locations other than the total reflection attenuation location detection in a surface plasmon sensor.

[0027]

[Effect of the Invention] According to the surface plasmon sensor of this invention, by having the first operation means which calculates based on the output from a photodetection means and this photodetection means which consists of a photodiode, and having detected the dark line location on the light-receiving side of a photodetection means, since it is immediately obtained as an analog signal, a total reflection attenuation angle can be measured at a high speed by considering a position signal as a result. Since the light-receiving side of a photodetection means can be taken in desired magnitude, it can take the large angle-of-incidence range of a light beam, and can make the dynamic range of measurement large. And since it is an analog signal, there is also no limit of the resolution by the component size seen with image sensors, such as CCD.

[0028] Therefore, it also becomes possible to realize the surface plasmon sensor which can realize a high speed, a high resolution, and an extensive dynamic range to coincidence and in which practical-like or two-dimensional 1-dimensional measurement [scan] is possible.
[0029]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to a detail with reference to a drawing. Drawing 1 shows the side-face configuration of the surface plasmon sensor concerning the gestalt of operation of this invention. So that it may be illustrated this surface plasmon sensor 1 The sensor unit 4 which consists of metal membranes 3 which consist of gold arranged on the glass substrate 2 and this glass substrate 2, silver, etc., and holds Sample S, Interface 2a of the light source 5 which consists of semiconductor laser which generates light beam L, and said transparence substrate 2 and metal membrane 3 It receives. It is above-mentioned interface 2a about light beam L. Optical system 6 which makes it converge and carries out incidence of each beam component to coincidence at an angle of a large number. Above-mentioned interface 2a It has a photodetection means (PSD) 7 to detect the quantity of light of light beam L which carried out total reflection, and an operation means 8 to calculate total reflection attenuation angle thetasp based on the quantity of light detected by this photodetection means 7.
[0030] In addition, in forming the metal membranes 3, such as gold, on a glass substrate 2, after arranging about 1nm of chromium beforehand on a glass substrate 2, it carries out. Formation of a metal membrane 3 becomes easy by this, and exfoliation is suppressed. Moreover, in analysis by the surface plasmon sensor, generally, the ligation reaction film (antigen (or antibody)) was formed on the metal membrane 3, the antigen and the antibody reaction which answers the specific matter alternatively were used, and it and the amount of antibodies (or antigen) to which it sticks specifically are measured as change of an incident angle.
[0031] Optical system 6 consists of the transparence substrate 2 of the sensor unit 4, prism 10 of the semicircle pilaster perpendicularly prolonged in space you are made to stick, cylindrical lenses 11 and 13 on which outgoing radiation light beam L is converged only in a field perpendicular to the major axis of prism 10 in the state of emission light from the light source 5, and a cylindrical lens 12 which carries out parallel Guanghua where this light beam L is seen from arrow-head A. In addition, a glass substrate 2 and prism 10 may form this glass substrate 2 and prism 10 in one, although made to stick through matching oil.
[0032] Since it converges as mentioned above according to an operation of cylindrical lenses 11 and 13, light beam L is the minimum incident angle theta 1 all over drawing. The maximum incident angle theta 2 It is interface 2a so that it may illustrate. The beam component of a large number which carry out incidence by two or more incident angles theta which receive and are mutually different will be included. In addition, let this incident angle be an include angle beyond a total reflection angle. Light beam L is interface 2a. Total reflection will be carried out and many beam components reflected by two or more angle of reflection from which this light beam that carried out total reflection also differs mutually will be contained.
[0033] It consists of three layers of I layer 18 which has in 16 on the front face of plate-like silicon, and has P layers in a rear face in the N layer 17 and the middle as shown in drawing 2 (b), and PSD7 is above-mentioned interface 2a. It is allotted so that all the beam components of light beam L which carried out total reflection may carry out incidence of the P layers to 16. In addition, an electrode 21 and 22 are prepared in the both ends of P layers, photo electric conversion of the light beam which carried out incidence to P layers is carried out, and a split output is carried out from an electrode 21 and 22 as a photocurrent.
[0034] Hereafter, the sample analysis by the surface plasmon sensor of the above-mentioned configuration is explained.
[0035] Generally, if an optical spot carries out incidence to PSD, the charge proportional to light energy will be generated in an incidence location. It passes along a resistive layer (in this case, P layers), using the generated charge as a photocurrent, and is outputted from the electrode of both ends. Since the resistive layer is made so that it may have uniform resistance in the whole surface, a photocurrent is inversely proportional to the distance (resistance) to an electrode, and is divided and outputted to it.

[0036] In PSD concerning this invention, a charge is generated, respectively in the incidence location of each beam component of this light beam that carries out incidence to PSD, it is inversely proportional to the distance from each location to two electrodes 21 and 22, and a photocurrent is divided. Therefore, total of the photocurrent generated by each beam component will be divided and outputted from two electrodes 21 and 22.
[0037] It is the photocurrent produced when the core between two electrodes 21 and 22 is made into a zero by having made the change direction of angle of reflection into x directions here and a light beam carries out incidence of the distance between two electrodes 21 and 22 to per unit length between L, two electrodes 21, and 22 I0 It carries out.
[0038] Before sample analysis, it is interface 2a first. The signals I10 and I20 outputted from two electrodes 21 and 22 where incidence of the light beam which has not produced the total reflection attenuation (ATR) which carries out total reflection is carried out between the two electrodes 21 of PSD7 and 22 are [0039].
[Equation 1]

$$I_{10} = I_{20} = \frac{L}{2} I_0$$

[0040] The positioning means which is not illustrated adjusts the physical relationship of the reflected light and PSD, and it positions so that it may become.
[0041] Sample analysis is performed, as it is the following after justifying in an above-mentioned procedure. The sample S for analysis is held at the condition of contacting the ligation reaction film on a metal membrane 3 on the sensor unit 4. And light beam L which converges as mentioned above in an operation of cylindrical lenses 11 and 13 is interface 2a. It turns and irradiates. This interface 2a Incidence of the light beam L which carried out total reflection is carried out to the light-receiving side (P layers) of PSD7.
[0042] Here, it is interface 2a. The beam component which carried out incidence by total reflection attenuation angle thetasp makes the interface of a metal membrane 2 and Sample S excite surface plasmon, and reflected light reinforcement falls keenly about this beam component. Therefore, interface 2a which carries out incidence on the light-receiving side of PSD7 The location as for which said beam component carries out incidence among the light beams which carried out total reflection serves as a dark line.
[0043] The two electrodes 21 of PSD7, the integral current value I1 by which a split output is carried out from 22, and I2 [0044]
[Equation 6]

$$I_1 = \int_{-\frac{L}{2}}^{\frac{L}{2}} \frac{1}{2}\left(1 - \frac{2}{L}x\right) I_0 dx = \frac{L}{2} I_0$$

$$I_2 = \int_{-\frac{L}{2}}^{\frac{L}{2}} \frac{1}{2}\left(1 + \frac{2}{L}x\right) I_0 dx = \frac{L}{2} I_0$$

$$\frac{I_2 - I_1}{I_2 + I_1} = 0$$

[0045] It comes out, and it is and both the integral current value is inputted into the operation means 8. In the operation means 8, it is based on this current value, and is [0046].
[Equation 3]

$$x_A = \frac{L(L-1)(I_1 - I_2)}{2(I_1 + I_2)}$$

[0047] It asks for a dark line location by the becoming operation.
[0048] The dark line location on a light-receiving side is interface 2a. It can respond to whenever [incident angle / which set and produced total reflection attenuation], total reflection attenuation angle thetasp can be obtained as a result by the above dark line location detection, and quantitative analysis of the special material in a sample can be carried out.

[0049] In addition, the above-mentioned surface plasmon sensor can be easily used as the surface plasmon sensor of-dimensional [1] or a two-dimensional mold. A-like or two-dimensional 1-dimensional scan can move the light source, optical system, and a photodetection means one-dimension-wise or two-dimensional to a sensor unit, and can be attained by making the location where it differs on an interface carry out incidence of the light beam one by one. What is necessary is just to have the tele cent rucksack scan optical system to which a light beam is made to deflect in the direction (the direction of Y) perpendicular to the space in drawing 1 according to the optical system equipped with the galvanomirror etc. in an above-mentioned surface-plasmon sensor for example, and an incidence location is moved, and a photodetection means migration means synchronize with migration of the incidence location in the interface of the light beam by this telecentric optical system, and make PSD7 move in the direction of Y, in order to consider as the surface-plasmon sensor of 1-dimensional scanning-type. Moreover, what is necessary is to install the optical system 6 and PSD7 containing prism 10 in a common conveyance base, to make optical system 6 and PSD7 move a conveyance base to an arrow-head Z direction as the second optical-system migration means and a photodetection means migration means, and just to enable the scan of the inside of ZY side two-dimensional in the above-mentioned surface plasmon sensor of 1-dimensional scanning-type, in order to consider as the surface plasmon sensor of a two-dimensional scanning-type.
[0050] Moreover, that an optical-system migration means and a photodetection means migration means should just be what performs relatively migration of the incidence location to said interface of a light beam, it may fix and optical system 6 and PSD7 may use-dimensional [1] or the sensor unit migration means to which it is made to move two-dimensional for the sensor unit itself as optical system and a photodetection means migration means.
[0051] Moreover, although PSD for 1-dimensional location detection was mentioned as the example and explained in the gestalt of the above-mentioned implementation, as it is shown in drawing 3 , they are electrode 21' of a lot, and 22'. It can already have the electrode 23 of a lot, and 24 in the perpendicular direction, and can also consider as two-dimensional location detection.
[0052] For example, what is necessary is just to detect the incidence location of the direction of a major axis of the light beam which only the scan length should spread in the direction of a major axis of prism 10, and moves the light-receiving side of PSD to it by scan by PSD in the surface plasmon sensor of the type which scans the incidence location to the interface of a light beam in the direction of a major axis of prism 10, and scans it in one dimension. in this case, about total reflection attenuation angle thetasp in each incidence location of the light beam to the sensor film The dark line location on PSD by the beam component which carried out incidence is detected like an above-mentioned case by this total reflection attenuation angle thetasp. The incidence location of the direction of a major axis of a light beam It is detectable by carrying out the split output of the photocurrent by the charge produced in this incidence location from these two electrodes 23 and 24 according to the electrode 23 of both ends, and the distance of 24. It is the current by which a split output is carried out from Iy0 and each electrode in the photocurrent which made the zero the core between M, two electrodes 23, and 24, and specifically produced the distance between two electrodes 23 and 24 by the light beam in which total reflection was carried out by the interface which carries out incidence between two electrodes 23 and 24, respectively I3 and I4 When it carries out and the incidence location to the direction of light-receiving side Y of a light beam is set to y, each split output is [0053].
[Equation 4]

$$I_3 = \frac{1}{2}\left(1 - \frac{2}{M}y\right)I_{y0}$$

$$I_4 = \frac{1}{2}\left(1 + \frac{2}{M}y\right)I_{y0}$$

[0054] Come out, it is, this output is inputted into an operation means, and it sets for an

operation means, and is [0055].
[Equation 5]

$$y = \frac{M}{2} \cdot \frac{I_4 - I_3}{I_3 + I_4}$$

[0056] The incidence location y should just be called for by the becoming operation.
[0057] In addition, the above-mentioned photodetection means can be used for various applications as a dark line location detection means to detect a dark line, only in a surface plasmon sensor.

[Translation done.]